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VERTICAL STRUCTURE OF SATURN'S EQUATORIAL IONOSPHERE AND MIDDLE NEUTRAL ATMOSPHERE

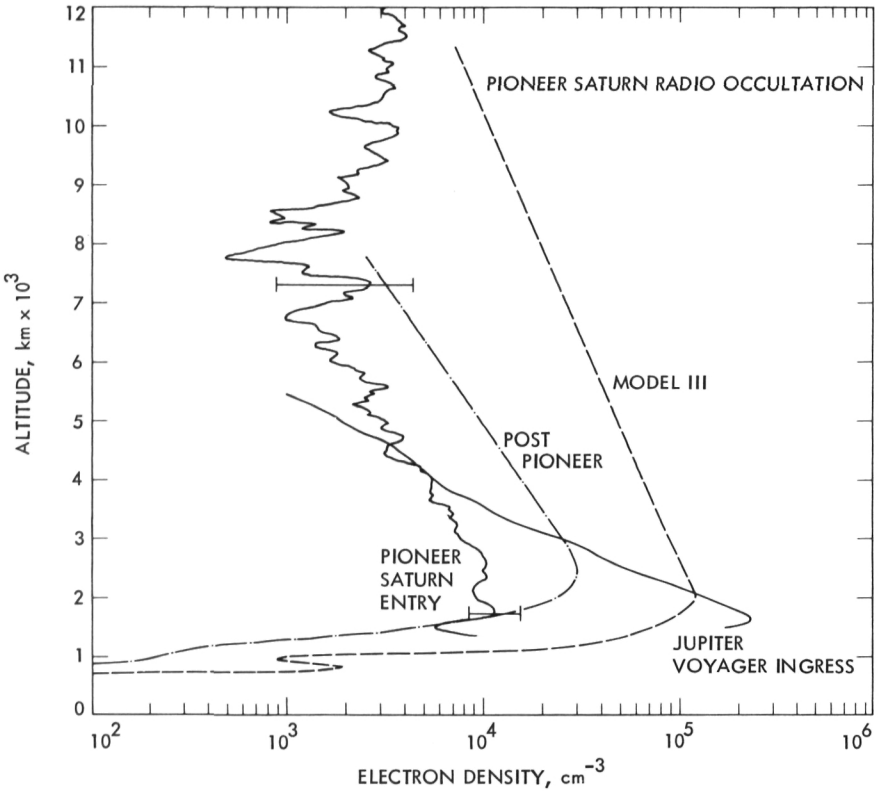
Radio occultation data at S-band frequency (2.293 gigahertz) collected during the close flyby of Saturn by the Pioneer 11 spacecraft in September 1979 produced important first results on the structure of the Saturnian ionosphere and middle neutral atmosphere near the equator. This was accomplished despite strong perturbations from fluctuations of solar wind plasma electrons resulting from the proximity of the Earth-Saturn line of sight to the sun of 8 degrees.

It was found that the principal electron density peak of the ionosphere occurs at an altitude of about 1800 kilometers and has a maximum density of 11,400 electrons per cubic centimeter, with a narrow lower peak of 9000 electrons per cubic centimeter, some 600 km below the main peak. The measured scale height indicates an exospheric temperature of about 1150 kelvins for an H^+ ionosphere. Ionization appears to extend to a radial distance of 80,000 km, with a broad peak of 7000 electrons per cubic centimeter at 74,500 km, corresponding to the radial distance of the inner edge of the C-ring.

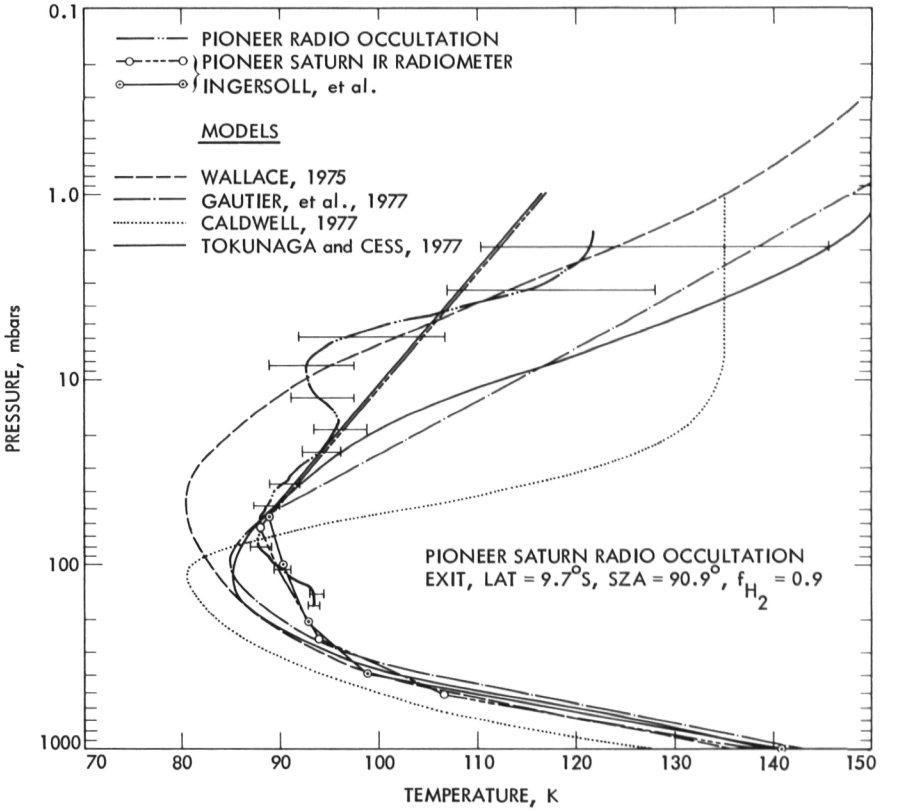
The unexpectedly low density of the main peak could be explained by the presence of an equatorial anomaly and by the effects of ring shadowing. The presence of significant ionization above the main peak, if real, could be explained if the main peak electron densities of about 100,000 electrons per cubic centimeter exist at higher latitudes, which are connected to the equatorial site of measurement by magnetic field lines. Plasmaspheric heating by Saturn's rings may also be important.

In the neutral atmosphere, measurements were carried out to the pressure level of about 180 millibars, showing the temperature inversion region having a triple minimum. The temperature at the principal minimum at an equatorial radius of 60,344 km is 88 ± 4 K at a pressure of 74 mbars, and there is another prominent minimum about 80 km above the principal one.

Comparisons of the temperature structure with the results derived from the Pioneer 11 Saturn Infrared Radiometer data suggest that the fraction of helium (by number) in the Saturnian atmosphere is 10 ± 4 percent, which is similar to the helium fraction in the atmosphere of Jupiter, as deduced by Voyager investigators.



Electron Density structure of the equatorial ionosphere of Saturn as determined from Pioneer 11 radio occultation data. Model III refers to a model by J. H. Waite et al., and the Post Pioneer model is one taking ring shadowing into account and computed for a solar zenith angle of 80 degrees. The remaining discrepancy between the observation and the model may be explained by equatorial anomaly.



The radio occultation temperature structure in the middle atmosphere of Saturn (curve with error bars) compared with Pioneer 11 infrared radiometer temperature retrievals (straight line segments) and several models based on ground-based infrared observations. The wavy nature of the radio occultation profile could indicate the effect of gravity waves, or it could be an artifact introduced by the spacecraft oscillator.